ART. XIX.—*Paleozoic Glaciation in Southeastern Alaska;*

by EDWIN KIRK.*

Evidence of glaciation in the Paleozoic is of interest even though the discovery of tillites has become the commonplace of geologic field work. During the past field season a tillite of Silurian age was found in southeastern Alaska. This is particularly interesting as being the first record of Silurian glaciation. Fairly conclusive evidence of Permian glaciation was also secured. There is some reason to believe that glacial deposits occur in the Devonian of the region as well.

Cairnes in 1914 described a conglomerate of "Permo-Carboniferous?" age which he found on the Alaska side of the international boundary just north of 65° north latitude. He considered the conglomerate as possibly of glacial origin. The conglomerate has a thickness of 700 to 800 feet and his description leaves little doubt but that it is a true tillite. One of his arguments against the probable glacial origin of the beds is that no other deposits of like character are known in Alaska. This objection has been met by the discovery of conglomerates in southeastern Alaska that apparently hold the same stratigraphic position and have most of the characteristic features of tillites. The conglomerate described by Cairnes has been accepted by Coleman as a tillite without question. Apart from this discovery of Cairnes no other paleozoic glacial deposits have been reported from Alaska.

The Silurian conglomerates which have proved to be of glacial origin were first noted by the Wrights¹ in their bulletin on the Ketchikan and Wrangell mining districts, Alaska. They were given an estimated thickness of 1200 feet and were placed within and at the base of the Lower Devonian. No special description of the conglomerates was given by the Wrights and no suggestion of possible glacial origin was made. These conglomerates are a conspicuous feature of the area on the west coast of Prince of Wales Island bordering on Davidson Inlet and Sea Otter Sound. The conglomerates are found scattered over an area of some 200 or 300 square

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¹ Wright, F. E. and C. W., U. S. Geol. Survey, Bull. 347, 1908.

miles in this immediate region, and further study would no doubt considerably extend the range to the south, east, and north. The best exposures of the Silurian glacial beds seen were on Heceta Island, although good outcrops are to be found on the south shore of Kosciusko Island, about 15 miles to the north. Apparently the same beds occur along El Capitan passage between Kosciusko and Prince of Wales islands. At the north end of Kuiu Island, some 125 miles to the north, a boulder bed holds the same stratigraphic position and, I believe, represents the same glacial deposit. Kosciusko and Heceta islands, where the best Silurian glacial deposits are to be found, lie between 55° and 60° north latitude, and 133° and 134° west longitude. These islands are situated on the west coast of Prince of Wales Island, toward the northern end. Prince of Wales Island is the large island of the south-eastern Alaska group, the southern point of which just clears the Alaskan-Canadian boundary. Kuiu Island lies to the north and slightly west of Prince of Wales Island.

The most favorable locality for an examination of the conglomerate is in the large bay about midway on the north shore of Heceta Island. The coast here is well protected from storms and there is a continuous outcrop of the limestone underlying the conglomerate, the conglomerate itself, and the overlying limestone. In places the conglomerate is well broken down by weathering, making the collection of pebbles and boulders an easy matter. As exposed, the beds outcrop along the shore between tide levels and give an outcrop perhaps 2000 to 3000 feet in length. The beds strike about N. 30° W. and have an average dip of about 30° N.E. At the east end of Heceta Island, on what is locally known as Blue Bluff, several hundred feet of the conglomerate are exposed in an abrupt face together with the basal portion of the overlying limestone. Both this exposure and that on the south side of Kosciusko Island are difficult of access except under exceptionally favorable weather conditions.

The glacial conglomerate is underlain and overlain by fossiliferous marine limestones. The succession of beds is clearly shown and unmistakable. The same relations can even more clearly be seen on the bold cliff at the east end of Heceta Island as to the upper limit of the conglomerate. The relations of the conglomerate to the under-

lying limestone are well shown on Kosciusko Island. The strata as a whole in this region are badly disturbed and, as is the case throughout southeastern Alaska, contacts are very poorly shown, being as a rule indicated by an indentation of the shore line and a depression running back into the timber. At present, therefore, although the relative positions of stratigraphic units are obvious, the character of the unconformity and the nature of the passage beds are only partly known.

The limestone series overlying the conglomerate carries a rich *Conchidium* fauna. In certain thin beds the rock is almost wholly made up of the brachiopods. This fauna appears to be identical with that of the limestone near Meade Point at the northern end of Kuiu Island. At the base of the limestone at this locality is a boulder bed which I believe to be glacial in origin and to be correlated with the conglomerate of Heceta. The limestones below the conglomerate likewise carry a rich fauna consisting of pentameroids, corals, and gastropods. The general aspect of both faunas seems to place them as approximately late Niagaran in age.

The conglomerate itself has a thickness of between 1000 and 1500 feet. It will probably be found to vary considerably from place to place. In the main the conglomerate appears to consist of heterogeneous, unstratified or poorly stratified material. Rarely lenticular bodies of cross-bedded sandstone occur in the mass. These are clearly water-laid and indicate current action.

The boulders in the tillite range in size up to 2 or 3 feet in length, as seen. They consist of greenstone, graywacke, limestone, and various types of igneous rocks; limestone boulders are scarce. All the boulders are smoothed and rounded. Facetted boulders are numerous, and given the proper type of rock, characteristic glacial scratches are common. The scratches show best on the fine-grained, dense greenstones. Limestone boulders and certain types of igneous rocks do not show them at all. The shore line is strewn with these pebbles and boulders which were undoubtedly derived from the conglomerate as they are not to be found on the adjacent limestone shores. All the material collected was taken from the conglomerate itself. This is well broken down by weathering in some places, and the pebbles may be picked out with the fingers or tapped out with the ham-

mer. When fresh the conglomerate as a rule is massive and exceedingly hard.

The nature of the deposit is such as to suggest a till. The heterogeneous character of the bowlders, both as regards size and material, and the apparent lack of stratification in the main, point to a true till rather than a submarine bed of ice-transported glaciated material. Such evidence as is at hand indicates that the Heceta area was very near the shore line and might easily have been land while the glacial material was being deposited.

The question of interglacial periods in the Silurian of the region can not at present be discussed with any degree of certainty. The finer points of stratigraphic succession are not known owing to the complex structural relations, the poorly shown outcrops, and the apparent lateral variation in character of sediments. I believe, however, that there are several distinct bodies of tillite separated by marine sediments. At the old Haida village of Klinkwan on the southwest coast of Prince of Wales Island and a few miles north of the west shore of Klakas Inlet are what I take to be beds of tillite interbedded with Silurian graptolite shales. The same condition obtains on the east shore of Dall Island in the neighborhood of View Cove. These tillites and shales I believe come above the limestone series overlying the tillite on Heceta Island. On Heceta Island itself, unless there has been considerable repetition by faulting, which does not seem probable, two or three distinct beds of tillite are indicated.

PERMIAN GLACIAL DEPOSITS.

In Pybus Bay, Admiralty Island, and on the Screen Islands off the west shore of Etolin Island are conglomerates strongly suggesting glacial material. In both cases these overlies high Carboniferous beds which have been correlated by Girty with the Gscshelian. Overlying the conglomerates are Upper Triassic beds. Where seen the conglomerates had not weathered down and it was not possible to obtain loose bowlders which might show scratches; faceted bowlders occur in the conglomerate, however. It will probably be found that this is a true glacial deposit and to be correlated with the conglomerate described by Cairnes near the Alaskan-Canadian boundary. A conglomerate similar to that described above

underlies the upper Triassic rocks of Dall Head, Gravina Island, and may prove of the same age and of similar character.

The occurrence of Permian glacial deposits in Alaska is of special interest inasmuch as most of the reported occurrences of tillites of this age have been in the tropics or to the south of the equator. Alaskan glaciation coupled with that near Boston, Mass., the two being possibly synchronous, indicate widespread glacial conditions in North America during this time. A conglomerate in southwestern California of approximately the same age is worth noting. This conglomerate is described in a U. S. Geological Survey Report, now in press, on the geology of the Inyo Range, California, by Adolph Knopf and Edwin Kirk. This conglomerate is composed of ill-assorted pebbles and boulders and carries contemporary potholes. Sandstones and conglomerates, probably to be correlated with this conglomerate, extend widely through Utah and Nevada and possibly correlate with the Weber. A careful study of these sediments offers interesting possibilities in the way of adding to our knowledge of land and possibly glacial conditions in Permian times.

POSSIBLE DEVONIAN GLACIATION.

In the *Stringocephalus*-bearing limestone zone of the Middle Devonian small faceted pebbles up to 2½ inches in length are of fairly frequent occurrence at one locality on the west coast of Prince of Wales Island. In Freshwater Bay and in Port Frederick, which lie near the northern end of Chicagof Island some 250 miles to the north, conglomerates occur in the Lower or Middle Devonian. Rounded boulders up to 2 feet in diameter were seen. They are very unlike normal sedimentary conglomerates. Should the boulders in the Devonian prove glacial, a somewhat different origin would probably be postulated for the conglomerates themselves. These are thin, ranging in thickness up to 25 feet or so, and would be more easily explained perhaps as consisting of berg-borne material, though glacial in origin. Bottoms of a similar nature are even now to be found in the channels of southeastern Alaska.

U. S. Geological Survey, Washington, D. C.